0022-3018/03/1915-332
THE JOURNAL OF NERVOUS AND MENTAL DISEASE

Vol. 191, No. 5
Printed in U.S.A.

Mixed Lateral Preference and Parental Left-Handedness

Possible Markers of Risk for PTSD

CLAUDE M. CHEMTOB, PH.D.,[1,2] and KRISTEN B. TAYLOR, PH.D.[1]

Degree of lateral preference (mixed versus consistent), family history of parental left-handedness, and presence of posttraumatic stress disorder (PTSD) were measured in 118 right-handed male U.S. combat veterans. Right-handed participants with mixed lateral preference were more likely to have PTSD than were right-handers with consistent lateral preference. Respondents reporting a left-handed parent were also more likely to have PTSD. Finally, there was a significant difference in the proportion of participants with PTSD for three groups: participants with parental left-handedness and mixed lateral preference (100% PTSD), participants with parental left-handedness or mixed lateral preference (70% PTSD), and participants with neither parental left-handedness nor mixed lateral preference (44% PTSD). These findings suggest the possible usefulness of further examining the relationship between mixed lateral preference, parental left-handedness, and other possible indicators of risk for PTSD.

—*J Nerv Ment Dis* 191:332–338, 2003

(5) May

There is an increased interest in identifying individual characteristics that may be associated with the risk of developing PTSD (Brewin et al., 2000). Chemtob and Hamada (1984) hypothesized that individual characteristics associated with a lesser degree of cerebral lateralization for language in right-handed people, such as female gender, mixed lateral preference, and familial left-handedness, are associated with a greater likelihood of developing PTSD (Watson et al., 1988). This neuropsychological hypothesis asserted that the right hemisphere plays a key role in the identification of threat and the regulation of emotion and that right-handed people with reduced cerebral lateralization for language (Hardyck and Petrinovich, 1977), as indexed by female gender, mixed-handedness, and familial left-handedness, would be more sensitive to threat and prone to experience emotion more intensely, because their cerebral organization was hypothesized to give greater relative primacy to right hemisphere contributions to ongoing cognitive processing.

Investigating this hypothesis, Spivak et al. (1998) found that mixed lateral preference among right-handed Israeli male combat veterans was associated with increased susceptibility to combat-related PTSD. Mixed-handed combat soldiers had a 65% likelihood of having PTSD, whereas the consistent right-handed veterans had a 43% rate of PTSD. Chemtob et al. (2001) reported that disaster-exposed adolescents with mixed lateral preference had more trauma symptoms as reflected in higher Impact of Event Scale scores (Horowitz et al., 1979) than did adolescents with consistent lateral preference. The current study attempted to replicate the findings reported by Spivak et al. (1998) in a sample of U.S. Vietnam veterans and to investigate whether parental left-handedness is also associated with an increased risk of PTSD. Finally, we assessed the effect of having mixed lateral preference and having a parent who is left-handed on the risk of PTSD.

Methods

Participants

There were a total of 350 potential respondents. All were male combat veterans who had served in the U.S. military. Participants were originally recruited for studies of PTSD conducted during the past 5 years. Participants in the previous studies included combat veterans with and without a PTSD diagnosis recruited through newspaper advertisements, posters, announcements to community organizations, Department of Veterans Affairs (VA) psychiatric clinics, local veteran centers, and mailings to VA patients.

Posttraumatic Stress Disorder Diagnostic Status

All participants were administered the Mississippi Scale for Combat-Related PTSD (Keane et al., 1988).

[1] National Center for Posttraumatic Stress Disorder, Pacific Islands Division, 1132 Bishop Street, Suite 307, Honolulu, HI 96813. Send reprint requests to Dr. Chemtob.
[2] Mount Sinai School of Medicine, New York, NY.

In addition, most participants had undergone a comprehensive psychiatric diagnosis that included psychometric measures and structured clinical interviews, either the Structured Clinical Interview, non-patient, Vietnam version (SCID-NP-V; American Psychiatric Association, 1987; Spitzer et al., 1989), or the Clinician Administered PTSD Scale (CAPS; Blake et al., 1990; Blake et al., 1995). The SCID-NP-V was used to measure the presence and absence of PTSD and to determine the presence of other psychiatric disorders. In some of the parent studies, the CAPS, a more detailed measure, was used to measure the presence or absence of PTSD in participants in the place of the PTSD module of the SCID-NP-V. Veterans meeting DSM-III-R (American Psychiatric Association, 1987) criteria for a diagnosis of organic mental disorder, psychotic disorder, current (within the past 30 days) substance abuse or dependence, or antisocial personality disorder were excluded from the parent studies and from the current study.

As noted above, as part of their evaluation for PTSD, all veterans were administered the Mississippi Scale, but diagnostic interviews were not available for all respondents. Because parental left-handedness and mixed lateral preference occur at relatively low base rates, we established PTSD diagnosis using the Mississippi Scale because it was available for all participants and thus increased power. This approach is similar to that used in the landmark National Vietnam Veterans Readjustment Study (Kulka et al., 1990). To validate this approach in our specific sample, we examined the concordance between diagnosis based on clinical interview and the Mississippi Scale cutoff for PTSD among those respondents for whom a structured clinical diagnosis was available. For the 44 veterans who had a PTSD diagnosis by SCID or CAPS, 93% also had a PTSD diagnosis by the Mississippi Scale cutoff score of 107 (Keane et al., 1988). For the 37 veterans who did not have a PTSD diagnosis by SCID or CAPS, 83% also did not have a PTSD diagnosis by the Mississippi Scale criterion. This high level of concordance between the clinician diagnosis and selection using the Mississippi Scale cut off supports the use of the cut-off to classify participants in this study as to whether they have PTSD.

Materials

Lateral Preference

We followed Annett (1970, 1972) in our classification of lateral preference. Annett was the first to propose characterizing people as consistent or mixed-handed. This takes into account that people who write consistently with one hand may regularly do a variety of other activities with the other hand. Using this classification system, fewer people (approximately 66%) are right-handed (consistent right-handers) than is usually described. Many (approximately 30%) are mixed right-handers, and the smallest numbers of people (approximately 4%) are consistent left-handers. Lateral preference was established using a modified Edinburgh Handedness Questionnaire (Oldfield, 1971). Participants were asked to indicate the hand they used for writing and whether they had been pressured to change writing hand, for drawing, for throwing a ball, for cutting with scissors, and for brushing their teeth. They were also asked to indicate their preferred kicking foot. The hand used for writing was used to classify participants as right- or left-handed (Annett, 1970). Right-handed respondents were defined as having consistent lateral preference if they reported a consistent right-side preference. If right-handed participants reported doing one of the queried activities with the left hand, foot, or eye, they were classified as having mixed lateral preference. Left-handed participants were not examined because of their small representation in the sample.

Parental Left-Handedness

Participants were asked to indicate whether either of their parents was left-handed. The report of a left-handed parent was considered evidence of parental left-handedness.

Combat Exposure Scale

The Combat Exposure Scale (CES) is designed to assess wartime stressors and provides a continuous index of the intensity and severity of combat exposure. Keane et al. (1989) reported good internal consistency (coefficient $\alpha = .85$) and reliability (1 week test-retest reliability = .97).

Mississippi Scale for Combat-Related Posttraumatic Stress Disorder

The Mississippi Scale (Keane et al., 1988) is a continuous measure of PTSD symptoms and of its associated features. It can also be used as a categorical measure to index the presence or absence of a PTSD diagnosis. Using a cutoff score of 107, Keane et al. (1988) reported a sensitivity of .93, a specificity of .89, and an overall efficiency of .90 in differentiating veterans with and without PTSD. Very strong additional support for the Mississippi Scale as a categorical measure of combat-related PTSD was provided by the National Vietnam Veterans Read-

justment Study (Kulka et al., 1990), in the course of which a lower cutoff of 89 was established. For the current study, the more conservative cutoff score of 107 was used to indicate PTSD.

Procedure

All participants had provided signed written consent to participate in studies in this laboratory and had given permission to be contacted for possible participation in future studies. Survey packets were mailed to participants with a cover letter explaining the purpose of the study and the confidential and voluntary nature of participation. Participants were informed in the cover letter that declining participation in the survey would not affect their benefits or continued treatment. As an additional measure to protect respondents, therapists treating veterans with PTSD in the VA clinic were informed of the survey. Survey packets included the Mississippi Scale and the lateral preference and parental handedness questionnaire. Reminder letters were sent to those who did not respond to the packet, approximately 6 to 8 weeks after the initial mailing. If no response to the reminder letter was received, a second packet was sent out, approximately 6 weeks later.

Results

Participants

Response Rate. We calculated the response rate using the method by Babbie (1973). Of the total 350 potential respondents, six were deceased and 63 were unreachable because of address problems and were excluded from consideration. Of the remaining 281 subjects, 143 responded to the mailing. This represents a response rate of 51%, which compares favorably with mail surveys of psychiatric patients (Baradell, 1995; Creamer et al., 1996).

Comparing Responders with Nonresponders. A strength of the study design was the ability to evaluate the possible impact of response biases introduced by responder self-selection because relevant data were obtained in the course of the veterans' previous participation in research. Responders were compared with nonresponders on age, marital status, branch of service, education, ethnicity, Mississippi Scale scores, and combat exposure. Survey responders were older (t [340] = 2.55, $p < .01$) and were less likely to be divorced (χ^2 [2, N = 330] = 6.94, $p < .04$) than nonresponders. However, responders did not differ from nonresponders on the key indices of Mississippi Scale scores (t [279] = .28, $p > .05$) and combat exposure (t [297] = .20, $p > .05$). They also did not differ on education level (t [315] = 1.45, $p > .05$) or on branch of service (χ^2 [2, N = 328] = .26, $p > .05$). White to nonwhite (*i.e.*, Native or part Native American, Asian, black, and Hispanic) proportions of veterans were similar for both groups (χ^2 [1, N = 335] = 1.56, $p > .05$).

Sample Representativeness. To evaluate sample representativeness, responders whose scores on the Mississippi Scale exceeded 106, indicating PTSD (Keane et al., 1988), were compared with 134 treatment-seeking veterans drawn from admissions to a specialized outpatient PTSD treatment unit whose scores on the Mississippi Scale also exceeded 106. The responder sample (N = 77) did not differ from the help-seeking group (N = 100) on Mississippi Scale scores (t [175] = .08, $p > .05$ and ethnicity (white versus nonwhite; χ^2 [1, N = 154] = .15, $p > .05$). Responders with Mississippi Scale scores greater than 106 were significantly older (t [175] = 4.29, $p < .01$) and had lower rates of divorce (χ^2 [2, N = 172] = 11.08, $p < .01$) than the outpatient help-seeking group. This comparison indicates that our group was not different on the key variables of combat exposure, Mississippi scores, and ethnicity from the help-seeking sample whose scores were in the PTSD range.

A similar comparison was made between responders scoring less than 107 on the Mississippi Scale (N = 66) and the corresponding help-seeking veterans scoring less than 107 (N = 34). The non-PTSD sample had a greater proportion of married veterans (χ^2 [2, N = 95] = 6.25, $p < .05$) and a trend toward being older (t [97] = 1.94, $p < .06$) than the corresponding help-seeking veterans. The two groups did not differ on Mississippi Scale scores (t [98] = 1.41, $p > .05$). The proportion of white to nonwhite veterans was approximately 50% for each group (χ^2 [1, N = 90] = .02, $p > .05$).

Lateral Preference and Posttraumatic Stress Disorder

Writing Hand. Writing hand was used to classify participants into right-handed and left-handed groups (Annett, 1970). One hundred eighteen participants reported writing with their right hand, and 23 subjects reported writing with their left hand. Two subjects were excluded; one reported being ambidextrous for the hand used for writing, and one did not report the hand used for writing. Because of the small number of left-handed participants, particu-

larly when subdivided into parental left-handedness and mixed versus consistent lateral preference groups, no further analyses were conducted with left-handed participants.

Mixed Lateral Preference and Posttraumatic Stress Disorder. To evaluate the relationship between mixed lateral preference and PTSD, the participants who reported using the right hand only to write were classified on whether they indicated a left preference (defined as using the left extremity or indicating being ambidextrous on that function) on any of the inventory items (throwing, brushing, drawing, cutting with scissors, or kicking). We then compared the frequency of PTSD among participants with mixed lateral preference (those who stated a left preference or ambidexterity on any of those items; $N = 26$) to the frequency of PTSD among those who indicated consistent right preference ($N = 92$). Participants with mixed lateral preference on the inventory items were significantly more likely to have PTSD than those with consistent right lateral preference on the inventory items (χ^2 [1] = 10.05, $p < .002$). Participants with mixed lateral preference were substantially more likely to have PTSD (80.8%) than not to have it (19.2%). In contrast, participants with consistent right lateral preference were slightly less likely to have PTSD (45.7%) than not to have it (54.3%). We also examined whether the respondents with mixed lateral preference had higher scores on the total Mississippi Scale (reflecting continuous symptom intensity scores) by using a *t*-test statistic. The respondents with mixed lateral preference had significantly more severe scores (mean = 122.27, t [116] = 3.13, $p < .002$) than respondents with consistent right-sided lateral preference (mean = 102.21). To control for the possibility that the two lateral preference groups may have been differentially exposed to combat, predisposing one or the other group to higher rates of PTSD, analyses were conducted comparing the mean CES scores between the groups. The two groups (mixed lateral preference and consistent lateral preference) did not differ on their mean CES score (t [111] = .194, $p > .05$). The association between combat exposure, mixed lateral preference, and PTSD diagnosis was also evaluated using chi-square analyses. Participants were split into two groups based on the median CES score. For those with high combat exposure, 93.3% of those with mixed lateral preference had PTSD, in comparison with 60.5% of the consistent right-handers (χ^2 [1, $N = 53$] = 5.5, $p = .02$). The results for participants with low combat exposure showed that 60% of those with mixed lateral preference had PTSD, whereas only 27.5% of the consistent right-handers had PTSD (χ^2 [1, $N = 60$] = 5.96, $p = .02$; Table 1). Therefore, it is unlikely that greater combat exposure led to greater prevalence of PTSD in the mixed lateral preference group.

TABLE 1
Percentages of mixed-handed and consistent-handed participants with and without PTSD grouped into high and low combat exposure by a median split on combat exposure scale scores

Median CES Split	Handedness Consistency	No PTSD	PTSD
High combat exposure	Mixed-handed	6.7%	93.3%
	Consistent-handed	39.5%	60.5%
Low combat exposure	Mixed-handed	40.0%	60.0%
	Consistent-handed	72.5%	27.5%

Parental Left-Handedness and Posttraumatic Stress Disorder

The association between having a left-handed parent and PTSD diagnosis was evaluated. Of the 118 right-handed respondents, 90.7% provided complete data on parental left-handedness ($N = 107$). Twelve percent of these respondents reported a left-handed mother or left-handed father. Right-handed participants who reported having a left-handed parent were more likely to exceed the cutoff score for PTSD (χ^2 [1] = 5.21, $p < .05$). Among participants with a left-handed mother or left-handed father, 83.3% (10 of 12) had PTSD, whereas a significantly smaller proportion of the participants whose parents were right-handed had PTSD, 48.4% (46 of 95). Participants with a left-handed parent also had significantly higher scores on the Mississippi Scale (mean = 126.08) than those without a left-handed parent (mean = 103.77, t [105] = 2.48, $p = .02$). To control for the possibility that the two parental handedness groups may have been differentially exposed to combat, predisposing one or the other group to higher rates of PTSD, analyses were conducted comparing the mean CES scores between the groups. The two parental handedness groups (left-handed parent and no left-handed parent) did not differ on their mean CES scores (t [105] = .694, $p > .05$). The association among combat exposure, parental left-handedness, and PTSD diagnosis was also evaluated using chi-square analyses. Participants with high combat exposure and parental left-handedness were more likely to have PTSD than those with high combat exposure but no parental left-handedness (80% versus 34%; χ^2 [1, $N = 55$] = 4.06, $p = .04$). Among the participants with low combat exposure, there was no significant difference in the proportion of those with and without parental left-

TABLE 2
Percentages of positive parental left-handedness and negative parental left-handedness participants with and without PTSD, grouped into high and low combat exposure by a median split on Combat Exposure Scale scores

Median CES Split	Handedness Consistency	No PTSD	PTSD
High combat exposure	+ Parental Left-handedness	20%	80%
	− Parental Left-handedness	66%	34%
Low combat exposure	+ Parental Left-handedness	14.3%	85.7%
	− Parental Left-handedness	35.6%	64.4%

TABLE 3
The percentages of each risk group that meet the diagnostic criteria for PTSD using the Mississippi Scale cut-off score

Mixed lateral preference and left-handed parent (N = 5)	Mixed lateral preference and no left-handed parent (N = 17)	Consistent lateral preference and left-handed parent (N = 7)	Consistent lateral preference and no left-handed parent (N = 78)
100%	70.6%	71.4%	43.6%

handedness who had PTSD (85.7% with parental left-handedness versus 64.4% without parental left-handedness; χ^2 [1, N = 52] = 1.25, $p > .05$; Table 2). It is unlikely that greater combat exposure led to greater prevalence of PTSD for those with parental left-handedness.

Mixed Lateral Preference, Parental Left-Handedness, and Posttraumatic Stress Disorder

To evaluate the possibly additive contributions of parental left-handedness and mixed lateral preference to risk for PTSD, a chi-square test was used to compare the proportions of right-handed subjects in our sample with PTSD among the same four groups: those with mixed lateral preference and parental left-handedness; those with mixed lateral preference, but without parental left-handedness; consistent right-handers with parental left-handedness; and consistent right-handers without parental left-handedness. The chi-square analysis (χ^2 [3] = 10.24, p = .03) showed a significant difference in the proportions of respondents with PTSD among the four groups. Among the men who reported doing something better with the left hand and who had a left-handed parent (N = 5), 100% had PTSD. Approximately the same percentage of those in the group of participants with consistent right preference but having a left-handed parent (71.4%, N = 7) had PTSD as those in the group of participants without a left-handed parent but who had mixed lateral preference (70.6%, N = 17). Only 43.6% (N = 78) of participants with consistent lateral preference and no parental left-handedness had PTSD (Table 3). Mean scores on the Mississippi Scale were calculated for each risk group. For participants with mixed lateral preference and parental left-handedness (N = 5), the mean score was 130.40. For participants with consistent lateral preference and parental left-handedness (N = 7), the mean score was 123.0. For participants with mixed lateral preference and no parental left-handedness (N = 17), the mean score was 117.5. For participants with consistent handedness and no parental left-handedness (N = 78), the mean Mississippi Scale score was 100.8. A one-way analysis of variance was not performed because of the unequal group sizes.

Discussion

The current study evaluated the incidence and severity of PTSD in relation to degree of lateral preference (consistent versus mixed) and in relation to having a left-handed parent (parental left-handedness) among right-handed Vietnam combat veterans. As predicted on the basis of the findings of Spivak et al. (1998), right-handed participants with mixed lateral preference were more likely to have PTSD than those with consistent right lateral preference. These findings, derived from examining a sample of U.S. combat veterans, support the results obtained by Spivak et al. (1998) among a sample of Israeli combat veterans with and without PTSD. In the study by Spivak et al. (1998), mixed-handed combat soldiers had a 65% likelihood of having PTSD, whereas the consistent right-handed veterans had a 43% rate of PTSD. Our study found that among participants with mixed lateral preference, 70% had PTSD, and only 44% of participants with consistent lateral preference had PTSD. In our sample, participants with mixed lateral preference also had significantly higher scores on the Mississippi Scale than those with consistent right lateral preference, indicating more PTSD symptomatology in the mixed lateral preference group. Chemtob et al. (2001) reported a related finding in a nonclinical population of disaster-exposed adolescents. Among that sample, participants with mixed lateral preference had higher scores on the Impact of Event Scale, a measure of trauma-related symptoms (Horowitz et al., 1979), than did participants with consistent lateral preference.

The current study extended the study by Spivak et al. (1998) by also examining the association of parental left-handedness to PTSD among combat veterans. Participants with a left-handed parent were significantly more likely to have PTSD than were those with right-handed parents. The proportion of participants with PTSD was ordered along a continuum from those with mixed lateral preference and parental left-handedness (100%), to those with either factor alone (70%), to those with neither factor

(44%). Although it is striking that 100% of the participants with mixed lateral preference and a left-handed parent had PTSD, because of the small size of this group ($N = 5$) in our sample, this result should be interpreted with caution and investigated further. The relatively small numbers of participants who had parental left-handedness or mixed lateral preference also limit these findings. This limitation should be addressed by conducting studies that recruit a larger number of participants. Although the rates of these two characteristics in the current sample were very similar to what has been reported before in the literature (Annett, 1970), those rates still yield small percentages because of the low proportions of people with mixed lateral preference, and especially parental left-handedness, in the general population.

This study indicates a relationship between mixed lateral preference and parental left-handedness and increased susceptibility to PTSD. It is not certain how to account for this relationship. Although mixed lateral preference and parental left-handedness have each been related to degree of hemispheric lateralization of language function, this study did not directly measure cerebral asymmetry using lateralized measures of emotional, visuospatial, or language processing. A follow-up study that directly examines the relationship between direct measures of cerebral asymmetry, personal characteristics such as mixed lateral preference and parental left-handedness, and the risk for PTSD would be needed to make the link between these variables. Such a study could evaluate the speculative hypothesis proposed by Chemtob and Hamada (1984) that these individual characteristics are markers of vulnerability for PTSD because they are indicators of the degree of hemispheric lateralization. The hemispheric lateralization hypothesis relies on data that suggest an association between degree of cerebral lateralization and these individual characteristics and on data suggesting that PTSD may be associated with lateralized hemispheric activation (Rausch et al., 1996; Shin et al., 1997).

Alternatively, mixed lateral preference and familial left-handedness may be nonspecific markers of vulnerability for psychopathology. This alternative hypothesis is consistent with a number of studies reporting increased susceptibility to psychopathology among people with these individual characteristics. For example, mixed lateral preference, but not left-handedness, was found to be associated with parent-reported problem behavior scores and self-reported delinquency scores among adolescents (Feehan et al., 1990), and degree of conduct disorder has also been related to degree of sinistrality (Grace, 1987). An atypical leftward shift in the handedness distribution among schizophrenics, characterized by an increase in mixed-handedness or ambiguous handedness was reported in Satz and Green's (1999) review. Associations between hysterical, antisocial, and explosive personality types and mixed-handedness have also been found (Standage, 1983). Examinations of anxiety disorders also suggest increased risk. For example, investigating agoraphobics, Le Boeuf (1986) found that mixed-handedness was significantly more frequent in male agoraphobics than in female agoraphobics or male controls. However, the handedness of female agoraphobics did not differ from that of female controls. In contrast, Chemtob et al. (2002) reported that people with phobias were more likely to report anomalous lateral preference.

Future research should attempt to replicate these intriguing findings by using larger samples that include patients with other trauma exposure and should examine the mechanisms that may account for the association between these individual characteristics and increased risk for PTSD. Such research holds the promise of permitting examination of the link among individual characteristics, neuropsychological markers of information processing, and vulnerability for PTSD. In addition, future studies could prospectively examine the risk of developing PTSD among persons differing with respect to these and other indicators of language lateralization.

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